

# Clip the wings of the Nuclear Regulatory Commission, and improve safety

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(2,484 words)

The Nuclear Regulatory Commission (NRC) was started<sup>1</sup> in 1975 as one of two successors<sup>2</sup> to the Atomic Energy Commission (AEC). As an independent commission, the NRC was to oversee nuclear energy, nuclear medicine, and nuclear safety.<sup>3</sup>

## NRCs safety regulation criticized

The AEC was felt to have been unduly favoring the industry it was regulating. Now the NRC has been under considerable criticism for the same issue – regulatory capture.<sup>4</sup> It is natural for a regulatory agency to favor the industry it regulates. After all, the agency would not exist without “its” industry and the heavy fees which it pays the regulator for services. However, a problem arises when the regulator ignores problems that could threaten public safety. The industry and regulator get any

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<sup>1</sup> The NRC is an independent agency of the United States government established by the Energy Reorganization Act of 1974.

<sup>2</sup> The second successor to the AEC was the Energy Research and Development Administration (ERDA) responsible for the development and oversight of nuclear weapons. Within ERDA the research and promotion of civil uses of radioactive materials, including nuclear non-destructive testing, nuclear medicine, and nuclear power was split into the Office of Nuclear Energy, Science & Technology. In 1977, ERDA became the Department of Energy (DOE). In 2000 the National Nuclear Security Administration was created with DOE responsible for nuclear weapons.

<sup>3</sup> The NRC regulates in three main areas:

- 1) Reactors – Commercial reactors for electric power generation, test and research reactors,
- 2) Materials – Uses of nuclear materials in medical, industrial, and academic settings and facilities that produce nuclear fuel,
- 3) Waste – Transportation, storage, and disposal of nuclear materials and waste, and decommissioning of nuclear facilities.

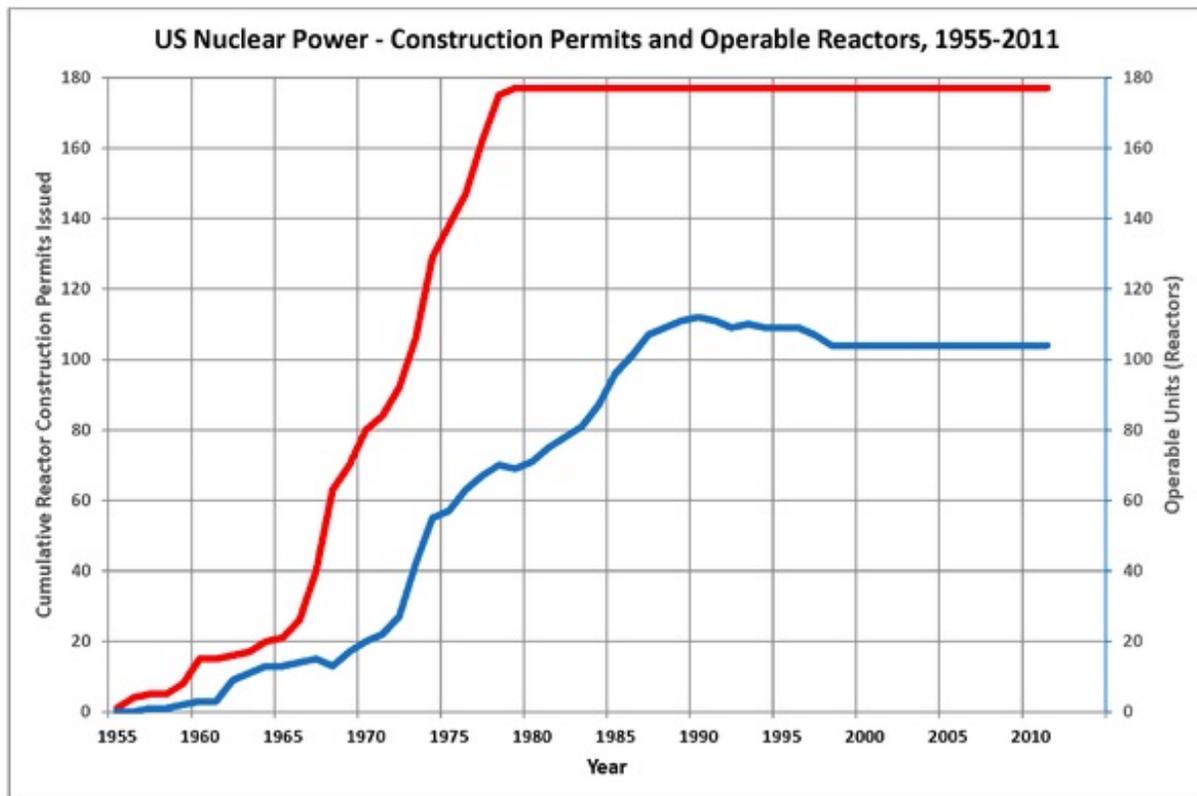
<sup>4</sup> In 1987 a Congressional report entitled “NRC Coziness with Industry” again complained about the usual tendency of regulators to ignore regulations for the benefit of “their” industry: U.S. House of Representatives, Committee on Interior and Insular Affairs, Subcommittee on General, Oversight and Investigations (1987). *["NRC' COZINESS- WITH" INDUSTRY" Nuclear Regulatory Commission Fails to Maintain Arms Length Relationship with the Nuclear Industry"](#)*. An Investigative Report 100th" Congress First Session. Retrieved 21 May 2014.

A summary of some of the criticism is contained in the [https://en.wikipedia.org/wiki/Nuclear\\_Regulatory\\_Commission](https://en.wikipedia.org/wiki/Nuclear_Regulatory_Commission) article under the headings, “Regulatory capture” and “Developments since 2011.” Note that many of the complaints are from organizations that totally oppose nuclear power generation or seek to cripple the power generation capability of the United States.

benefit, but the public takes the risk. This imbalance in who takes the risk and who gets the reward from safety regulation can be corrected, but will require a significant change to the NRC's mandate.

## Safest form of power generation

In terms of lives lost per unit of energy generated, nuclear fission power is the safest yet discovered. Since American commercial nuclear generating plants have not released sufficient radiation to kill anyone,<sup>5</sup> all estimates are purely theoretical extrapolations based on worst case assumptions. By contrast about 100 people a year are killed transporting fuel to coal plants. Coal mining kills over 100 times as many miners as does uranium mining. Gas and petroleum production and distribution regularly produce fatalities. Dams for hydroelectricity generation occasionally collapse with horrible loss of life. Even solar, because of its dilute nature, is more hazardous than nuclear power. Petr Beckman estimates that replacing a 1,000 MWe<sup>6</sup> coal plant with a nuclear plant will save very roughly between 20 and 100 lives a year.<sup>7</sup>



US reactor construction permits issued and operating nuclear power reactors, 1955-2011 (data from EIA)

<sup>5</sup> A US Army experimental test power reactor, SL-1 underwent a steam explosion and meltdown on 03 Jan 1961, killing its three operators. This event is the only reactor incident in the US which resulted in immediate fatalities. Fatalities in the Ukraine as a result of the flawed Chernobyl reactor (1986), in the Soviet Union with the Kyshtym explosion (1956), in the UK with the Windscale fire (1957), and in Japan as a result of lack of training at Tokaimura (1999), received lots of press but were dwarfed by the more common deaths due to other forms of power generation.

<sup>6</sup> MWe is the abbreviation for megawatts of electrical power capacity. Reactors are often rated by their thermal capacity (MWt) which is about 3 times larger since the conversion of heat to electricity is not particularly efficient.

<sup>7</sup> [https://en.wikipedia.org/wiki/Nuclear\\_power](https://en.wikipedia.org/wiki/Nuclear_power) & Beckman, Petr. *The health hazards of NOT going Nuclear*. Boulder CO: Golen Press. 1977 (with additions to cover the Three Mille Island accident).

## Nuclear plant construction hiatus

The first US commercial nuclear power reactor became operational in 1957 and plants were added steadily. Reactor construction permits, which averaged 12 per year from 1967 through 1978, came to a complete halt after 1979. No new permits were issued until 2012 when four new permits were issued. Many permitted reactors were never built. Finally, on 19 October 2016, the first reactor in 20 years entered service in the US.<sup>8</sup>

The NRC, itself, described its regulation of the long-delayed Seabrook Nuclear Plant as “a paradigm of fragmented and uncoordinated government decision making” and “a system strangling itself and the economy in red tape.”<sup>9</sup>

Capital costs are the critical element in building nuclear power stations. It is estimated that for new US plants built in the current decade capital costs will comprise 74% of the cost of the electricity produced. Regulatory expenses are significant and begin well before construction. The interest cost for these up-front expenses as well as any regulatory delays encountered before the plant can generate electricity add very significantly to the plant's cost. Thus gas-fired plants, that do not face this extreme regulatory burden, are commonly selected, even though the fuel costs<sup>10</sup> are much lower for the nuclear plant.

The NRC obviously played a significant role in running costs so high as to make nuclear plants unaffordable. The heavy hand of bureaucracy appears to have strangled the child it was mandated to regulate.

The incredible delays in expanding the nuclear power generating industry can not be laid entirely at the door of the NRC. High interest costs,<sup>11</sup> much lower power demand, and public protests also led to the 33-year hiatus in new construction permits.

Nonetheless, a new method of insuring the safety of nuclear power generation needs to be developed.

## Innovation

Innovation is another area that can be adversely affected by regulation.<sup>12</sup> A recent example has been the lack of ability of the NRC to process applications for small power reactors in a timely and cost-

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<sup>8</sup> The very long delayed Watts Bar Unit 2 (its construction permit was issued in 1973!) joins six other operating TVA nuclear reactors to supply more than one third of the generating capacity in the region.

<sup>9</sup> [https://en.wikipedia.org/wiki/Nuclear\\_power\\_in\\_the\\_United\\_States](https://en.wikipedia.org/wiki/Nuclear_power_in_the_United_States). In the section “Three Mile Island and after”, see paragraph 6. The Seabrook Plant was permitted for two reactors in 1976, after many delays the first began full power operation in 1990. The second reactor was canceled and most of its components sold to other plants.

<sup>10</sup> Costs of raw uranium vary tremendously, but have little impact on the cost of the electricity produced. At current prices the raw uranium costs less than 0.15 cents/kWh in a light water reactor and less than 0.0015 cents/kWh in a breeder reactor. Of course by the time it is enriched and manufactured into fuel rods it is much more expensive.

<sup>11</sup> Nuclear power plants use low cost fuel but require very high capital costs and construction is quite slow. Both high interest rates and regulatory changes can drive costs to two or more times the direct construction cost.

effective manner. Major power reactors usually have power generation capabilities in excess of 1,000 megawatts,<sup>13</sup> while small power reactors are 300 megawatts or less. Four reactors of 12MWe each are operating in Russia,<sup>14</sup> and small reactors are in construction in other countries, but not in the US.

Small reactors have value working in remote locations:

- far from major population centers, and
- isolated from major electrical grids.

Small modular reactors (SMRs) are planned to be constructed in factories and transported to site. This will result in saving major on-site labor costs and increasing quality control.<sup>15</sup>

SMRs are also being investigated as alternatives to costly larger plants since small reactors can be added incrementally at lower capital costs.

The most common nuclear plants in the US require refueling about every two years. Thus SMR facilities with multiple reactors have an advantage since a small percentage of their total power is off line at any time. The large plants in the US produce power about 90% of the time with much of their down time devoted to refueling.

The NRC's inability to approve any of the many designs for small nuclear reactors has stymied progress in this area. In the US alone eight companies have SMR designs at various stages of development.<sup>16</sup>

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<sup>12</sup> “The Effects of Federal Regulation on Chemical Industry Innovation” by J.Clarence Davis: <http://scholarship.law.duke.edu/cgi/viewcontent.cgi?article=3725&context=lcp> discusses many of the regulation the impinge on this large and diverse industry (55,000 chemicals, 11,500 companies). Product registration statutes only affect some of the food drug, cosmetic, insecticide, fungicide, and rodenticide portions of the chemical industries. Most chemical plant regulation is of the liability and penalty type and therefore is applied only in the case of an actual accident. That means that actual plant operations are regulated by the insurance industry which employs the engineers who can evaluate the dangers that many of these exceeding dangerous and complex plants pose.

<sup>13</sup> As of December 2015 there were 99 operating nuclear power plants in the US. The smallest was Fort Calhoun in Nebraska with one reactor at 479 megawatts. The largest is Palo Verde in Arizona where three reactors combine for a generating capacity of 3,937 MW. If the Palo Verde plant operated at full capacity for 24 hours it would produce 94,488 megawatthours (MWh).

<sup>14</sup> The four small Russian reactors are at the Bilibino Nuclear power plant in the Chukotka Autonomous Orug. The EGP-6 are light water graphite reactors (LWGR) with a thermal capacity of 62 MWt or a gross power capacity of 12 MWe each. They have been operating since 1974-76.

<sup>15</sup> Stephen Monk, of Lancaster University, has an easily read description of both the advantages and disadvantages of SMRs at: <http://theconversation.com/everything-you-need-to-know-about-mini-nuclear-reactors-56647>. The UK has budgeted funds for a competition to select a “best value” design of a SMR and is currently in Phase one of that competition..

<sup>16</sup> As of September 2014: [https://en.wikipedia.org/wiki/List\\_of\\_small\\_nuclear\\_reactor\\_designs](https://en.wikipedia.org/wiki/List_of_small_nuclear_reactor_designs):

- Babcock & Wilcox has a 180 MW pressurized-water basic design (mPower) based on their highly successful submarine power plant,
- Holtec International has a 140 MW pressurized-water conceptual design (SMR-160),
- Hyperion Power Generation has a 25 MW lead-cooled fast reactor conceptual design (HPM),
- Westinghouse has a 100 MW pressurized-water basic design (IRIS-100),
- GE Hitachi has a 311 MW fast-breeder reactor detailed design (S-Prism),
- Intellectual Ventures has a 10 MW traveling-wave conceptual design (TerraPower),
- Westinghouse has 225 MW pressurized-water preliminary design (Westinghouse SMR),

None of these are anywhere near being permitted for construction, although South Korea, and Russia have a small plants (100 MWe and 295 MWe) licensed, and Argentina has a 27 MWe plant under construction.

Toshiba offered the small Alaskan town of Galena a free 10 MWe reactor with a 30 year fuel supply if they would help with approval and provide the concrete buildings. After meetings and presentations to the NRC it was found that they were not set up to evaluate small reactors and their procedures would impose such tremendous cost as to make the project a financial disaster.<sup>17</sup> The project was indefinitely postponed and may not be revived.<sup>18</sup> Toshiba's 4S fast-neutron liquid metal design was sealed and provided no access to local operators. Although similar designs had run for decades at US nuclear research facilities, the NRC could not get up to speed in a reasonable time frame.

## The DOE tries to promote small nuclear reactors

Meanwhile, the Department of Energy, Office of Nuclear Energy (DOE-NE) has positioned SMRs as a key part of its "Nuclear Energy Research and Development Roadmap." They began in FY12, the SMR Licensing Technical Support (LTS) program to get designs certified, licensed, and sited. They are currently supporting preparation and review of one certification and its first-of-a-kind engineering design as well as two site licensing projects.

Thus we have one federal agency (The DOE) trying to help satisfy the regulatory requirements of another public agency (the NRC). Good luck guys!

The DOE selected NuScale Power<sup>19</sup> for SMR funding of effective designs that offer performance beyond those currently certified by the NRC. In February 2016, Utah Associated Municipal Power Systems was granted site access within the Idaho National Laboratory to investigate sites for an SMR.<sup>20</sup> NuScale also has ambitions to be a major player in the United Kingdom SMR field. In July 2016 NuScale provided funding to Sheffield Forgemasters International Ltd to develop the manufacturing techniques and perform a demonstration forging of its reactor vessel head.<sup>21</sup>

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- NuScale Power has a 45 MW light water-basic design (NuScale), and
  - X-Energy has a 35 MW high-temperature gas-cooled conceptual design (Xe-100).

<sup>17</sup> Permitting costs for the 4S reactor technology could reach \$600 million and site permitting would be at least \$50 to \$70 million. <http://energy-alaska.wikidot.com/galena-nuclear>

<sup>18</sup> Marvin Yoder, who was the Galena City Manager, has written a book: The Galena Nuclear Project: Pursuing Low Cost Energy in Bush Alaska. He gives little hope of the project's revival in the foreseeable future because the NRC cost is just too high. This in spite of the special fit that a passive safety, 30 years with no refueling, sodium cooled, low maintenance, high inherent security, fast reactor has for remote locations with little local technical expertise (personal communication).

<sup>19</sup> <http://www.nuscalepower.com/>

<sup>20</sup> <http://www.energy.gov/ne/articles/department-energy-continues-commitment-development-innovative-small-modular-reactors>

<sup>21</sup> <http://newsroom.nuscalepower.com/press-release/nuscale-forges-ahead-northern-powerhouse>

The NRC has finally started paying attention to SMRs, and are now discussing pre-application design certification with NuScale Power.<sup>22</sup>

## Three Mile Island

The partial meltdown on 28 March 1979 of reactor 2 at Three Mile Island (TMI) in Dauphin County Pennsylvania was the United States' most serious nuclear power incident.<sup>23</sup> There were no injuries or adverse health effects, although the reactor was destroyed.<sup>24</sup> The incident caused public confidence in nuclear power, particularly in the US, to decline sharply. This, along with the high interest rates of the 1970s, regulatory bureaucracy, and lower demand, stopped new nuclear construction in the 1980s, 1990s and into the new century. While projections for reactor growth in the early 1970s suggested 1000 reactors by 2000, the actual peak number was 112. Retirements have since dropped this number to 100.

Analysis of the TMI incident has suggested a number of changes in the way nuclear plants are run, operators are trained, and component reliability is evaluated.<sup>25</sup> The possibility of multiple human errors, compounded with undetected mechanical faults is now taken much more seriously.<sup>26</sup> Control systems design, which in the 70s was more appropriate to a coal fired power plant than a nuclear reactor, was reviewed. Human-factor engineering specific to nuclear power was non-existent at that time.

One insurance company chemical engineer after examining the TMI control room said his company would not insure a plant with such obsolete controls.<sup>27</sup> He said the controls looked like they were designed by a committee whose thought processes were frozen in WWII.

In spite of the scathing reviews of the reactor controls, the NRC was loath to get involved in forcing significant upgrades.

## Safety oversight in the chemical industry

Liability laws, rather than regulation, govern the safety of chemical plants. Many plants in the very diverse chemical industry are significantly more dangerous than nuclear power plants.<sup>28</sup> However,

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<sup>22</sup> <http://www.nrc.gov/reactors/advanced/nuscale.html>

<sup>23</sup> On 22 Mar 1975 at Brown's Ferry, Unit One workers resealing a cable penetration between the cable spreading room and the reactor building accidentally set a temporary seal on fire. The fire spread to a number of cables and caused significant damage to the control cables related to Units 1 and 2. Unit One was shut down for a year while repairs were made. This incident led to substantial additions to NRC's fire protection standards.

<sup>24</sup> A good general description of the accident is at: [http://www.threemileisland.org/science/what\\_went\\_wrong/](http://www.threemileisland.org/science/what_went_wrong/). A more detailed description is at: <http://www.engineering.com/Library/ArticlesPage/tabid/85/ArticleID/172/Three-Mile-Island.aspx>.

<sup>25</sup> Under "Impact of the Accident", the NRC provide a summary of these enhancements: <http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/3mile-isle.html>

<sup>26</sup> IEEE Spectrum, November 1979, *Nuclear Power and the Public Risk*, P.59, see section on *Human Factors*, p.61

<sup>27</sup> Many of the chemical plants he monitored for his insurance company were significantly more dangerous than a nuclear power plant.

insurance companies have specialized engineers that assess the risks and mandate safety training, rules, and equipment before chemical plants can obtain insurance.

Since the chemical industry grew up in an era when government regulation was not as pervasive as it is in the post WWII period the public was largely protected by liability law.

In contrast the nuclear industry was created by government, promoted by government, and government/academia had all the initial expertise, so regulation by government seemed to be the only path forward. Little consideration was given to the effect that liability law has in developing insurance company expertise and effective private efforts toward public safety.

Now that the nuclear power industry has matured, it may be time to consider the chemical industry's example and move toward a liability model.

The insurance industry, while not wanting to kill its customers, is also not willing to assume more risk than is absolutely necessary. Thus, it is incented to regulate the safety of chemical plants, while also keeping them as viable customers.

The NRC, on the other hand, has legislative directives to insure safety, but only through written rules and regulations. Often these are so costly that no new (and safer) plants can be built. Like most regulatory agencies their stake in safety is only legislative, and does not directly affect the NRC's income. The public takes the risk.

The insurance industry has a direct stake (through liability laws) in the safety of the plant, its workers, the surrounding public, and the environment. Thus can be expected to provide a practical regulation that is responsive to each plant's overall safety. Its incentives to keep chemical plants productive, but extremely safe is very high since their profitability is dependent on achieving both goals.

In the nuclear power industry the NRC has no comparable skin in the game. Whether a plant is built or retired has little financial impact on the organization.

## **Current nuclear plant insurance**

The Price-Anderson Act<sup>29</sup> of 1957 has been amended and extended to 2025. Owners of each reactor unit pay a premium each year for \$375 million of offsite liability coverage. This first tier insurance is supplemented by a second tier assessed to each licensee as a prorated share that covers damages up to \$111.9 million. With 100 reactors currently licensed, this fund can be tapped for as much as \$11.19 billion. This would cover the costs of incident response, precautionary evacuation, investigating claims, defending claims, settling suits for everything associated with operating a reactor including fuel and waste transportation and the acts of any subcontractor or supplier.

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<sup>28</sup> Beckman. Petr. *The health hazards of NOT going Nuclear*. Boulder CO: Golen Press. 1977 (with additions to cover the Three Mille Island accident).

<sup>29</sup> [http://www.naic.org/cipr\\_topics/topic\\_nuclear\\_liability\\_insurance.htm](http://www.naic.org/cipr_topics/topic_nuclear_liability_insurance.htm)

At present American Nuclear Insurers (a consortium of large American insurance companies) writes all policies and retains about one third of the risk. The rest is placed with reinsurers around the world.

Since 1957 insurance has paid out about \$151 million for claims and the Department of Energy has paid out about \$65 million.

After the Three Mile Island incident, insurance paid out about \$1.2 million in evacuation claims, although no evacuation was ordered. Lost wages claims were settled and although no health claims have been substantiated, insurance companies have paid approximately \$71 million in claims and litigation costs.

## **Liability and insurance; not NRC regulation**

There is a way to improve public safety and health, encourage innovation, bypass regulatory capture, reduce the regulatory expense, and build more reactors.

We need to take the lead from the chemical industry, where liability laws promote safe operation. Rules and regulations are an inefficient way to achieve safety. They specify the way safety is to be achieved (often ignoring technical and control advances), rather than specifying the goal and letting the operating company (checked by their insurance engineers) find the best and most efficient way to achieve that goal.

## **Changing the NRC**

The NRC needs to qualify insurance companies to provide proper liability insurance, and stop their detailed regulation of nuclear plants. To keep costs in line, multiple insurance companies must be qualified to compete for the business.

It needs to propose changes to Price-Anderson insurance so the size of the required coverage is more closely proportional to the size of the plant and the safety of its design. Small plants simply cannot afford to pay for coverage appropriate to a large plant. Modern plant designs bear few of the risks that are present in older plants. Insurance coverage limits should reflect this. A greater emphasis needs to be made on the first-tier insurance, since the insurance rates for this will be determined by the safety the operators display in maintaining and running each individual plant. The second-tier program provides a significant backstop, if a really catastrophic accident were to occur, but must not be a substitute for individual plant insurance.

The NRC's Operations Office of Nuclear Regulation needs to become the Office of Nuclear Insurance Qualification (many of the current staff engineers will be in demand by the insurance industry). It should propose the changes to Price-Anderson as well as qualifying the required insurance companies. The office of Nuclear Regulatory Research needs to become the Office of Reactor Safety Audits.<sup>30</sup> They should conduct occasional audits of selected plants to evaluate how well the safety program is being implemented. They can then recommend changes.

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<sup>30</sup> The Commission has eight staff offices dealing mostly with their legal, congressional, financial, public affairs, international contacts, and the all important Office of the Executive Director for Operations.

## President Trump has leverage to reform the NRC

The five Commissioners who run the NRC are appointed by the President and confirmed by the Senate. There are currently two vacancies and the remaining three have terms expiring in the middle of 2017, 2018, and 2019.<sup>31</sup> Trump will have the ability to nudge the NRC toward the a faster moving yet safer future.

The NRC has about 3,900 personnel and a budget of about \$1.06 billion, of which about 90% is recovered by fees.<sup>32</sup> Thus, the changes suggested above will not significantly affect the budget, but they will free a maturing industry from the dead hand of an overwhelming bureaucracy.

A new fleet of modern reactors would be an important part of President Trump's goal to update the US infrastructure.

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The Executive Director for Operations oversees 17 operations including the major Offices of:

- Federal and State Materials and Environmental Management Programs,
- New Reactors,
- Nuclear Material safety and Safeguards,
- Nuclear Reactor Regulation, and
- Nuclear Regulatory Research
- Enforcement,
- Investigations,
- Nuclear Security,
- Region I (New England down thru PA, DE, and MD),
- Region II (WV, VA, KY, TN, NC, SC, GA, AL & FL),
- Region III (MN, WI, MI, IA, MO, IL, IN & OH),
- Region IV (all the remaining states),
- Information Services,
- Computer Security,
- Administration,
- Chief Human Capital Officer, and
- Small Business and Civil Rights.

<sup>31</sup> Stephen G. Burns is the current chairman/spokesman and will end a 5-year term on 30 June 2019. Commissioner Kristine L. Svinicki is serving a second term that ends on 30 June 2017. She is the most technically qualified of the Commissioners. Commissioner Jeff Baran is serving a term that end on 30 June 2018. The remaining 2 commission seats are currently vacant.

<sup>32</sup> NRC's proposed FY 2015 budget was \$1,059.5 million, with 3895.9 full-time equivalents (FTE), 90 percent of which is recovered by fees. This was a slight increase from FY2014.